ABSTRACT

The purpose of this study is to develop an application named RFID Marathon Timing System by using radio frequency identification device (RFID). RFID is a wireless non-contact technology that using radio frequency electromagnetic fields to transfers data from a tag attached to an object, for the purposes of automatic identification and tracking. In marathon competition, it is impossible to get accurate stopwatch readings for every entrant and display the result immediately. In this thesis, RFID Marathon Timing System is used to tracking the timing for each participant of marathon competition and display the result of each participant immediately. This system is developed by using Rapid Application Development methodology. First is compare and analyzes the RFID Marathon Timing System and the conventional timing system by compare the functions and operation. Next is design the structure and flow of RFID Marathon Timing System. RFID Marathon Timing System is analyzing in detail by its features and operations. Next is the development phase, RFID Marathon Timing System is developed and tested. Results of this RFID Marathon Timing System are it able to capture the timing of each participant and able to display result of each participant when they crossing the finish line. Furthermore, the result also showed that this RFID Marathon Timing System could be used as an alternative timing system for bicycle racing, triathlon and so on.

ABSTRAK

Kajian in dilakukan bertujuan membina satu sistem bernama RFID Marathon Timing System dengan bergunakkan alat identifikasi frekuensi radio. RFID adalah sebuah teknologi wayarles tanpa kontak langsung dengan menggunakan gelombang radio untuk hantar isyarat dari tag kepada object dengan bertujuan untuk identifikasi dan menjejaki. Dalam pertandingan maraton, sangat susah untuk mendapatkan bacaan masa untuk setip peserta dan serta-merta memaparkan keputusan untuk setiap peserta. Dalam tesis ini, RFID Marathon Timing System digunakkan untuk mendapatkan bacaan masa untuk setiap peserta dalam pertandingan maraton dan memaparkan keputusan untuk setiap peserta serta-merta. Sistem ini dibinakkan dengan mengunakkan metodologi Rapid Application Development. Langkah pertama adalah untuk membandingkan dan menganalisis RFID Marathon Timing System dengan konvensional Timing System dari segi fungsi dan operasi. Langkah seterusnya adalah reka struktur dan aliran sistem RFID Marathon Timing System. RFID Marathon Timing System dianalisis secara teliti daripada ciri-ciri nya dan operasional. Dalam fasa seterusnya, RFID Marathon Timing System dibinaan dan diujikan. Keputusan daripada RFID Marathon Timing System ialah sistem ini dapat menangkap masa untuk setiap peserta dan dapat memaparkan keputusan untuk setiao peserta serta-merta apabila mereka melalui barisan tamat. Keputusan ini juga menujunkkan sistem RFID Marathon Timing System boleh digunakkan dalam pertandingan basikal, triathlon dan lain-lain.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The purpose of chapter 1 is to introduce to the readers about the project that will be developed later. This chapter contains Introduction, Problem Statement, Objective, Scope and Thesis Organization.

1.2 BACKGROUND

Traditionally, the early timing system operating by using manual, for example: stopwatch. By using manual method to records time for marathon event, not only large of data need to records and also a lot of manpower needed to operate the system. For example: in marathon event, need a lot of manpower to register each participants, records timing for first 50 participants, updates score and update ranking by manually. This kind of manually system easy to made mistakes due to human factor. For example: speed of human being when pressing a stopwatch and time factor when deal with large of data. In order to solve this problem, RFID Marathon Timing System based on the radio frequency identification device (RFID) is developed. By using RFID Marathon Timing System, time used to register each participants can be reduce and rush error are avoided since everyone can finish in anytime without being in a batch mode. This is because RFID Marathon Timing System cans records the finish time of each participant and updates their score and ranking. In RFID Marathon Timing System have two main devices, RFID tags and RFID readers. An RFID tag is attached to the participants. An RFID tag is emits a unique code different with each other. Then an RFID tag is detected by RFID readers located at the finish line. When the RFID tag is detected by RFID readers, the RFID Marathon Timing System will immediately records the current timing of the participant and show the current timing and ranking of each participant. RFID Marathon Timing System is suitable for running marathon event.

1.3 PROBLEM STATEMENT

Capturing data is always a challenge because it deal with lot of manpower to manage and manipulate the data and human limitation while records timing for each participant. Capturing data in a race environment can be even more difficult. As events draw very large numbers of participants, so it is very difficult to measure the timing for every entrant and also very hard to get the accurate timing for every entrant due to human error. For example: speed of human when pressing stopwatch, errors in problem detection and problem may occur during races when two participants reach the finish line in almost same time. RFID Marathon Timing System can also act as checkpoint station because some participants may reach the finish line early without registered.

1.4 OBJECTIVE

Objective of the RFID Marathon Timing System is:

- To get timing reading for each participants.
- Able to manage data of participants and display the result instantly.
- To replace operators pressing a stopwatch.

1.5 SCOPE

Participants

- RFID Marathon Timing System only for marathon.
- The participant should wear the RFID tag.

Environment

- Open area without interfere of radio frequency.
- The finish line must inside the detection range.

1.6 THESIS ORGANIZATION

This thesis consists of five chapters. Chapter 1 will discuss on introduction to system. In Chapter 1 contains Introduction, Problem Statement, Objective, Scope, and Thesis Organization.

Chapter 2 is Literature Review. In this chapter will review and analyzing the work of literature in relation to the system.

Chapter 3 is Methodology. This chapter will discuss the approach and framework for the project. Method, technique or approach that will be used while designing and implementing the project will be included in the content.

Chapter 4 is Implementation. This chapter will explain about the designed project development on how the database and table that will be designed and use of equipment.

Chapter 5 will discuss on the results and data analysis. In Chapter 5 contains Result analysis, Project limitation and Suggestion and project enhancement.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter briefly discusses on literature review related with the proposed project. The first section will introduce about RFID technology and fundamental concepts of RFID. Second section will discuss about RFID components. The next section will explain the communication between tag and reader. The last section will discuss about the existing RFID application.

2.2 FUNDAMENTAL CONCEPTS OF RFID

Radio frequency identification (RFID) technology uses radio waves to automatically identify physical objects, either living beings or inanimate items. The range of objects identifiable using RFID includes virtually everything on this planet. Thus, RFID is an example of automatic identification (Auto-ID) technology by which a physical object can be identified automatically.

RFID is a technology that users radio waves to transfer data from an electronic tag. A wave is a disturbance that transports energy from one point to another.

Electromagnetic waves are created by electrons in motion an consist of oscillating electric an magnetic fields. This type of waves can pass through a number of different material types [1] [2].

The highest point of a wave is called a crest and the lowest point is called a through [1].

The distance between two consecutive crests or two consecutive troughs is called the wavelength [1].

One complete wavelength of oscillation of a wave is called a cycle [1].

The time take n by a wave to complete one cycle is called its period of oscillation [1].

The number of cycles in a second is called the frequency of the wave and the frequency of the wave is measured in hertz (Hz). If the frequency of a wave is 1 Hz, it means that the wave is oscillating at the rate of one cycle per second. It is common to express frequency in KHz, MHz, or GHz [1] [2].

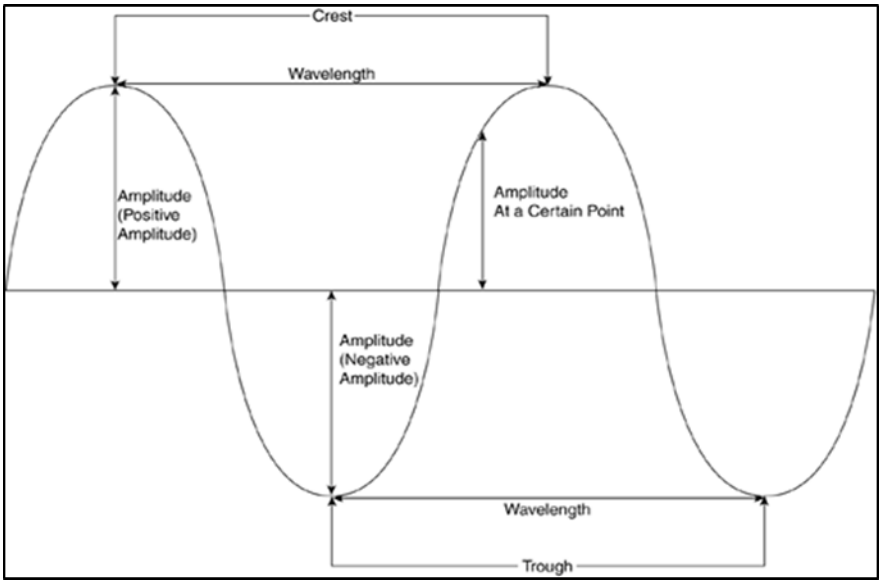

Figure 2.1:: Parts of Wave

Amplitude is the height of a crest or the depth of a trough from the undisturbed position [1][2]. The formers are also called the positive amplitude and the latter is called the negative amplitude. In general, the amplitude at a certain point of a wave is its height or depth from the undisturbed position, and is called positive and negative accordingly [1] [2].

Radio frequency waves are electromagnetic waves with wavelengths between 0.1 cm and 1,000 km or with frequencies lie between 30 Hz and 300 GHz. Example of electromagnetic wave types are infrared, visible light wave, ultraviolet, gamma ray, x ray, and cosmic ray. RFID uses radio waves that are generally between the frequencies of 30 KHz and 5.8 GHz. Modulation refers to the process of changing the characteristics of a radio wave to encode some information bearing signal. Modulation can also refer to the result of applying the modulation process to a radio wave [3].

Classes of RFID frequency types include the following:

- Low frequency (LF)
- High frequency (HF)
- Ultra high frequency (UHF)
- Microwave frequency

Low frequency is a frequency between 30 KHz and 300 KHz. RFID systems commonly use the 125 KHz to 134 KHz frequency range. RFID systems operating at low frequency (LF) generally use passive tags, have a low data transfer rates from the tag to the reader, and are especially food if the operating environment contains metals, liquids, dirt, snow, or mud. Active low frequency (LF) tags are also available from vendors. Because of the maturity of the type of tag, low frequency (LF) tag systems probably have the largest installed base. The low frequency (LF) range is accepted worldwide [3] [5].

High frequency (HF) is ranges from 3 MHz to 30 MHz with 13.56 MHz being the typical frequency used for high frequency (HF) RFID systems. A typical high frequency (HF) RFID system uses passive tags, has a slow data transfer rate from the tag to the reader and offers fair performance in the presence of metals and liquids. High Frequency (HF) systems are also widely used, especially in hospital because it does not interfere with the existing equipment [3] [5].

The rage of ultra-high frequency (UHF) is from 300 MHZ to 1 GHZ. A typical passive ultra-high frequency (UHF) RFID system operates at 315 MHz and 433 MHz.

An ultra-high frequency (UHF) system can therefore use both active and passive tags and has a fast data transfer rate between the tag and the reader, but performs poorly in the presence of metals and liquids. Ultra-high frequency (UHF) systems have been started being deployed widely because of the fast data transfer rates [4] [5].

Microwave frequency range upward from 1 GHz. A typical microwave RFID system operates either at 2.45 GHz or 5.8 GHz, although the former is more common, can use both semi-active and passive tags, has the fastest data transfers rate between the tag and the reader and performs very poorly in the presence of metals and liquids. Because antenna length is inversely proportional to the frequency, the antenna of a passive tag operating in the microwave range has the smallest length. The 2.4 GHz frequency range is called Industry, Scientific, and Medical band and is accepted worldwide [3] [5].

Table 2.1: RFID Frequency Ranges

Frequency Range	Band	Read Range	Advantages	Disadvantages	Applications
Low frequency	125 KHz-134 KHz	Below 0.5 meter	Operates well around water and metals; accepted worldwide	Short read range; slow read rates	Animal tracking Access control Vehicle immobilizers Product authorization
High frequency	13.56 MHz	Below 1 meter	Low cost of tags; accuracy; quick read	Require a higher power	Item tracking Airline baggage

			rates		Smart Cards Libraries
Ultrahigh frequency	860 MHz-930 MHz	3 meters	Frequency selected by EPCglobal	Does not operate well near water or metals	Supply chain and logistics Automated toll collections Parking lot access
Microwave frequency	2.4 GHz	1 meter	Fastest read range	Does not operate well near water or metals	Supply chain and logistics Airline baggage Electric toll collections

2.3 COMMON RFID COMPONENTS

An RFID system consists of the following components from an end to end perspective:

- Tag. This is a mandatory component of any RFID system.
- Reader. This is a mandatory component.
- Antenna. This is another mandatory component. Some of the current readers or scanners available today have built-in antennas.
- Controller. This is a mandatory component. Nowadays, most of the new generation readers or scanners have this component built in to them.

- Host and software. An RFID system can function independently without this component, but an RFID system is close to worthless without this component.
- Communication infrastructure. This is mandatory component is a collection of both wired and wireless network and serial connection infrastructure needed to connect the previously listed components together to effectively communicate with each other.

2.3.1 Tags

Tags are the devices attached to the items or material that the RFID system is intended to track. The tags may be attached or placed directly on individual items such as in the case of customer goods or on shipping containers or pallets that hold multiple items. The tags come in all sort all sizes and shapes.

There are three primary types of tags produced: passive, semi-passive, and active. Passive tags do not have an interior power supply, and therefore they must rely on the scanners or readers for power. Active tags possess batteries that supply power for communication. Because of this reason, active tags can significantly improve the range between the tag and the interrogator. A hybrid of the active and passive tags, the semi-passive tag possesses a low cost batter that is used to power the tag’s onboard electronics. The battery does not allocate power for increasing the tag’s communication range [9].

The function of the tag is to transmit data to the rest of the RFID system. Tags generally contain three basic parts: the electronic integrated circuit, a miniature antenna, and a substrate to hold the integrated circuit and the antenna together and to the inventory item [9]. Tags have various memory structures and data capacities. Therefore, there are numerous methods of retrieving and transmitting information with RFID tags. Tags will transmit and receive information according to the type of information it stores and the specific commands of an interrogator. In systems using first generation protocols, tags from one vendor did not talk to interrogators from another vendor. All types of tag memory can perform basic read and write tasks. The RFID tag costs are directly associated with the complexity or memory read and write functions [6].

Tag memory is designed in three ways: Read-Only (RO), Write Once Read Many (WORN), or Read-Write (RW) [9]. In terms of complexity and cost, each tag type has advantages and disadvantages according to its memory type. A Read-Write tag may cost more and provides a greater functionality, but a Read-Only tag provides more security and ease of use [9]. All type of memory can be used in passive, semi-passive and active tags.

A passive tag is so named because it cannot generate and reflect radio signals to a reader if it is not in the presence of an electromagnetic field. A passive tag must be inside the interrogation zone in order to receive enough power to generate a response. The initial interrogator signal powers a passive tag's circuitry, allowing the tag to function [6] [7].

Semi-passive tags are the least used in the RFID industry. Semi-passive tags make use of the initial electromagnetic wave produced by the interrogator to generate communication. In this way, the operating principle of the semi-passive and passive tags is the same: both only operate when they receive a signal from the interrogator, and can only transmit when they receive adequate power from a source. The tags use their own batteries to run circuitry [8].

Semi-passive tag additional battery power allows them to resist interference or circumvent a lack of power from the original interrogator signal. The transmission signal sent back to the interrogator is stronger than that of passive tags, which allows tags to transmit across longer distances and sustain operation for the proper amount of time during information transaction. Like passive tags, the size of semi-passive tags can vary depending on their range and functionality. Because of their batteries, semi-passive tags are large than passive tags. Battery powers in semi-passive tags also increase memory capacity, which allows room to implement large components. These tags can remain in operation for extended lifetimes, but their batteries need to be monitored and eventually replaced [8] [9].

Active tags contain their own battery source, broadcast their own signal to a reader, and therefore do not rely on the reader for power. Because of this internal power, active tags achieve the greatest read ranges and some active RFID tags can send a signal one kilometer. In some cases, an active tag can be integrated with a Global Positioning System (GPS) to pinpoint the exact location of an item. A tag operating all of the time will act as a type of beacon, broadcasting its location at specified intervals [9].

Active tags are the largest compare to passive and semi-passive tags because of their batteries. Typical active tags have a thickness of approximately one-half inch and a surface area of 1.5 $\times$ 3 inches. Greater tag size also allows for more memory capacity and functionality. The information contained in an active tag can be more complex than that in a passive or semi-passive tag. Active tags can store an object's standard serial number as well as the full list of contest in the container, the container destination, and the origin of the container. With all of this information available, active tags offer up to date supply chain information. As with semi-passive tags, active tag's batteries have finite lifetimes and will need to be maintained or replaced accordingly [9].

Table 2.2: RFID Technologies Comparison

Type of tag	**Power source**	**Range**	**Size**	**Data storage**	**Cost**
Passive	External electromagnetic antenna field	Measured in feet	Smaller	Less	Less
Semi-Passive	On-board battery for internal circuitry. External electromagnetic field for transmission	Measured in feet	Larger	More	More
Active	On-board battery	Up to thousands of feet	larger	More	More

2.3.2 Readers

An RFID reader is also called an interrogator, is a device that can read from and write data to compatible RFID tags. Thus, a reader also doubles up as a writer. The act of writing the tag data by a reader is called creating a tag. The process of creating a tag uniquely associating it with objects is called commissioning the tag. Similarly, decommission a tag means to disassociate the tag from a tagged object and optionally destroy it. The time during which a reader can emit RF energy to read tags is called the duty cycle of the reader.

The reader is the central nervous system of the entire RFID hardware system, establishing communication with and control of this component is the most important task of any entity which seeks integration with this hardware entity.

A reader has following main components:

- Transmitter

  The reader's transmitter is used to transmit AC power and the clock cycle via its antennas to the tags in its read zone. This is one part of the transceiver unit, this component responsible for sending the reader's signal to the surrounding environment and receiving tag responses back via the reader's antenna. The antenna ports of a reader are connected to its transceiver component, one reader antenna can be attached to each such antenna port [11] [12].

- Receiver

  Receiver is also one part of the transceiver module. It receives analog signals from the tag via the reader antenna. It then sends these signals to the reader's microprocessor, where it is converted to its equivalent digital form that is, the digital representation of the data the tag has transmitted to the reader antenna [10] [9].

- Memory

  Memory is used for storing data such as the reader configuration parameters and a list of tag reads. Therefore, if the connection between the reader and the controlled of software system goes down, not all the read tag data will be lost. Depending on the memory size, however a limit applies as to how many such tag reads can be stored at any one time. If the connection remains down for an extended period with the reader reading tags during this downtime, this limit might be exceeded and part of the stored data lost. That is overwritten by the other tags are read later [9].

- Microprocessor

  Microprocessor is responsible for implementing the reader protocol to communicate with compatible tags, it is performs decoding and error checking of the analog signal from the receiver. In additional, the microprocessor might contain custom logic for doing low-level filtering and processing of read tag data [11] [12].

- Communication interface

  Communication interface provides the communication instructions to a reader that allow it to interact with the eternal entities, via a controller to transfer its stored data and to accept commands and send back the corresponding responses. you can assume that this interface component is either part of the controller of is the medium that lies between a controller and the external entities. This entity has important characteristics that make it necessary to treat this as an independent component. A reader could have a serial as well as a network interface for communication. A serial interface is probably the most widespread type of reader interface available, but the next generation readers are being developed with network interfaces as a standard feature. Sophisticated readers offer features such as automatic discovery by an application, embedded Web servers that allow the reader to accept commands and display the result using a standard Web browser, and so forth [11] [12].

2.3.3 Antennas

RFID antenna is used to transmit the radio frequency signal from reader to the tags. RFID antenna is also used to receive the radio frequency signal from the tag for subsequent processing by the RFID reader [9].

Normally, where the orientation of the tag with the respect to the reader will not change, it is possible to have a single antenna. This can work in manufacturing applications where a product is undergoing a process. However, in more complex situations where the orientation of the tag is not guaranteed, it is normal for RFID systems to utilize more than one antenna. For a given sized interrogation zone for an antenna, the greater the number of antennas, the greater the probability of a successful read by the system [9] [11].

RFID antennas are commonly contained within an outer rectangular shaped plastic housing. The housing protects the antenna and associated electronic components from damage. The housing also protects the antenna from minor environment hazards such as dust. Thus, many RFID antennas have little resemblance to the type of antenna that may be used to seeing. The plastic housing also provides a means of attaching the antenna in position.

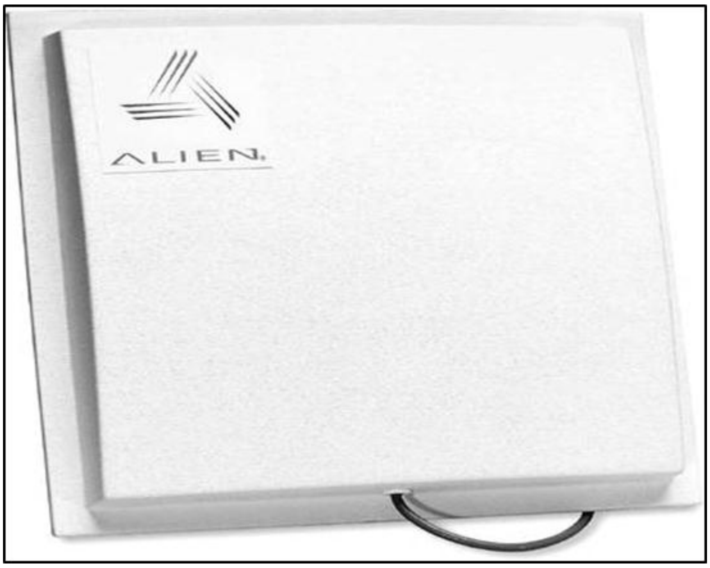

Figure 2.2: RFID Antenna with Rectangular Shaped [24]

Positioning of the RFID antenna is also an important issue. Both the packaging material and the item to be tracked can affect the ability of the RFID system to conduct a successful read. In a forklift type application, the antennas may be positioned above the driver's safety cage. In a shrink wrap application, the antennas would be positioned in locations around the turntable, which would still allow access to the table.

Another antenna placement issue is the height of the antenna. In some applications, the material will not necessarily be passing through a specific portal. In many cases, the range of the antenna and the size of the interrogation zone can be increased by raising the antenna above ground level. Some experimentation will be necessary in order to determine the optimal sized zone [9].

Another possible antenna issue is a situation where the antenna cannot be allowed to interfere with the surface movement of the material. In situations like this, it is possible to mount the antenna suspended from the ceiling with the field oriented downwards. This method works particularly well when the tags can be placed on the topmost horizontal surface. In this case, the system has an unobstructed view of the tags and the successful read rate is likely to be very high.

2.3.4 Controller

A controller is an intermediary agent that allows an external entity to communicate with and control a reader's behavior together with the annunciators and actuators associated with this reader. Controller is the only component of an RFID system or reader through which reader communications are possible, no other medium or entity provides this ability. A controller for a reader can be embedded inside the reader or can be separate component by itself. To retrieve tag data stored on a reader, a computer must use a controller. Computer cannot communicate to the reader in any other way. A controller also provides a communication interface for the external entities to interact with it [9].

2.3.5 Host and Software

Host and software system is an all-encompassing term for the hardware and software component that is separate from the RFID hardware. The system is composed of the following two main components:

- Edge interface

  Edge interface is the software that runs on the host computer that interfaces with the reader. With standalone interrogator systems that do not require a host computer to operate, edge interface runs on the interrogator. It allows configuration of the interrogator's functions, including the read rate, power level, frequency of operation, and method to poll tags. Edge interface may organize some information by consolidating multiple reads from one tag or eliminating responses from item level tags when only case tag information is desired [13].
- Middleware

Middleware is for the data collection, management, and flow among the tags, interrogators, and inventory applications. It plays an important role in the business justification for RFID applications. Middleware communicates the data collected by the interrogators to the application layer software, such as inventory management software used to make business decisions. Without this middleware, the data collected by RFID installations cannot be easily integrated into the decision making process. Middleware is often written by a different vendor than the interrogator and the application software vendor, but can be customized to each customer's requirements [9] [13].

2.3.6 Communication Infrastructure

This component provides connectivity and enables security and systems management functionalities for different components of an RFID system, and is therefore an integral part of the system. It includes the wired and wireless network, and serial connection between readers and computers. Common types of protocols include RS-232 and Ethernet-based systems.

RS-232 is the simple protocols to be available with an RFID system. This serial protocol is commonly utilized in industry to communicate directly between a host computer and one or more devices via individual dedicated cables. This port has either nine or twenty-five pins. RS-232 suffers from slow data transfer rates of 20K and limited transmission cable lengths of fifty feet. While some transmission distance issues may be overcome, other issues may make another protocol more attractive. For example, RS-232 cable is more expensive than other alternatives such as Ethernet. Despite many industry announcements of the death of RS-232, the protocol continues to be utilized in the industry environment [14].